

Test Results and Modeling of the Honda Insight using ADVISOR

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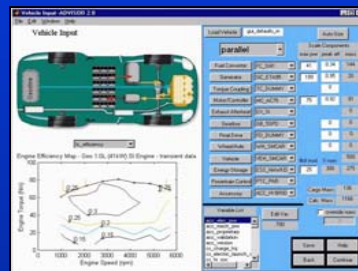


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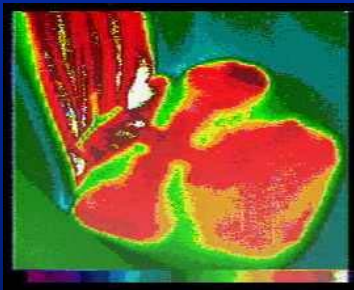


NREL Vehicle Testing and Modeling

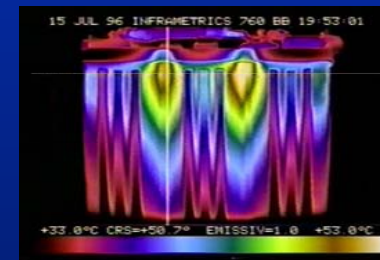
Interdisciplinary



Vehicle Systems Analysis



Vehicle Climate Control



Battery Thermal Management



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Vehicle Testing Objectives

Measure the impact of air-conditioning on fuel economy and emissions

Study the behavior of the battery pack under various conditions

Develop temperature dependent battery pack model(s) for ADVISOR

Model correlation and development of accurate ADVISOR vehicle model



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NREL's Vehicle Testing Partner: **Environmental Testing Corp (ETC)**

Private emissions certification and R&D laboratory

Located 30 minutes from NREL in Aurora, Colorado

Key ETC customer: Daimler/Chrysler (*on-site testing presence*)

Customers Served in 2000 include:

Ford, Daimler/Chrysler, GM, Volvo, Jaguar, Hyundai, Isuzu

Recognized by EPA for High Altitude Emissions Certification

Previous NREL/DOE Experience testing Alternative Fuel Vehicles



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TECHNOLOGIES AND SYSTEMS



Environmental Testing Corp (ETC) : Capabilities

- 40,000 sq ft (3700 m²) test facility on 5 acres
- Emissions Certification and Fuel Economy
 - *Four independent, temperature-controlled chassis test cells (-45 to 45 C) - including 48" electric dynamometer*
 - *bag, modal and second-by-second analysis*
 - *chemical analysis laboratory*
 - *user defined driving cycles and temperatures*
 - *catalyst efficiency*
 - *diesel particulate*
 - *customizable data acquisition*
- Evaporative Emissions, Running Loss, and On-Board Refueling Vapor Recovery (ORVR)
- Engine Dynamometer Testing
- Drivers Aid and Dynamometer Control Software



Vehicle Testing Data Acquisition

Battery temperatures, voltages,
and currents (20 Hz)

- 30 cell temperatures
- 10 cell voltages
- inverter current
- auxiliary load current

Cabin temperatures

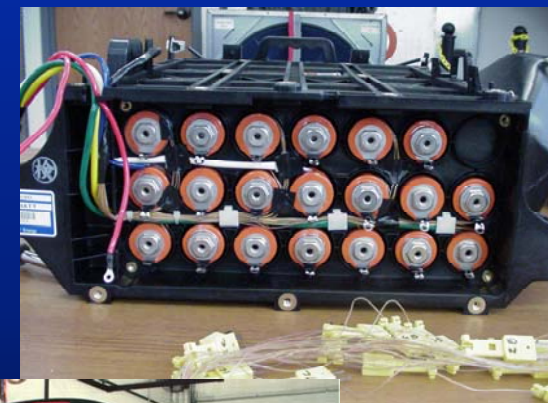
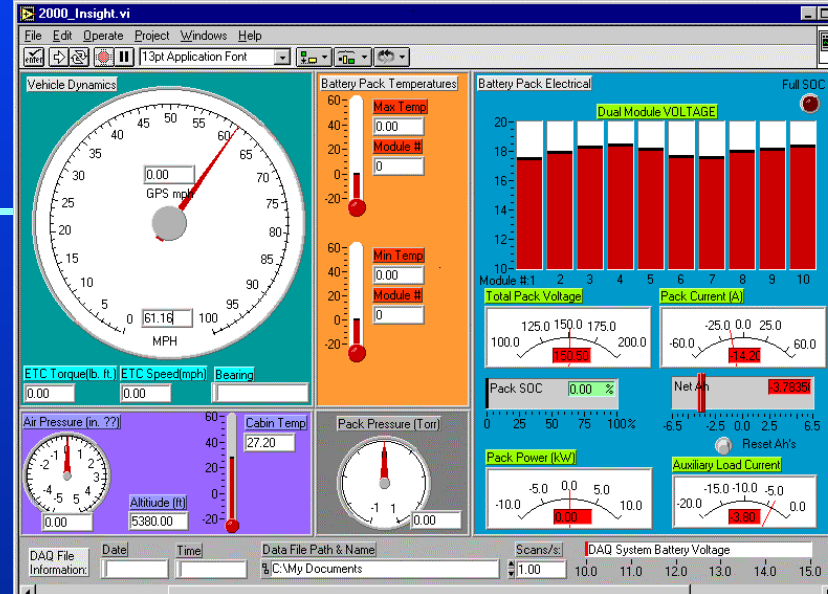
- driver, passenger, roof
console

Vehicle Operating Parameters

- engine speed, map,
vehicle speed, throttle
position, engine coolant,
intake air temp, O₂

Emissions Data

(20Hz, bag, and modal analysis)



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Vehicle Testing

Test Procedures

Chassis Dynamometer Test Procedures

- *FTP-75*
- *US06 (0, 20, 40 degrees C)*
- *SC03 (95 degrees F, with and without A/C)*
- *HWFET*

On-Road Testing

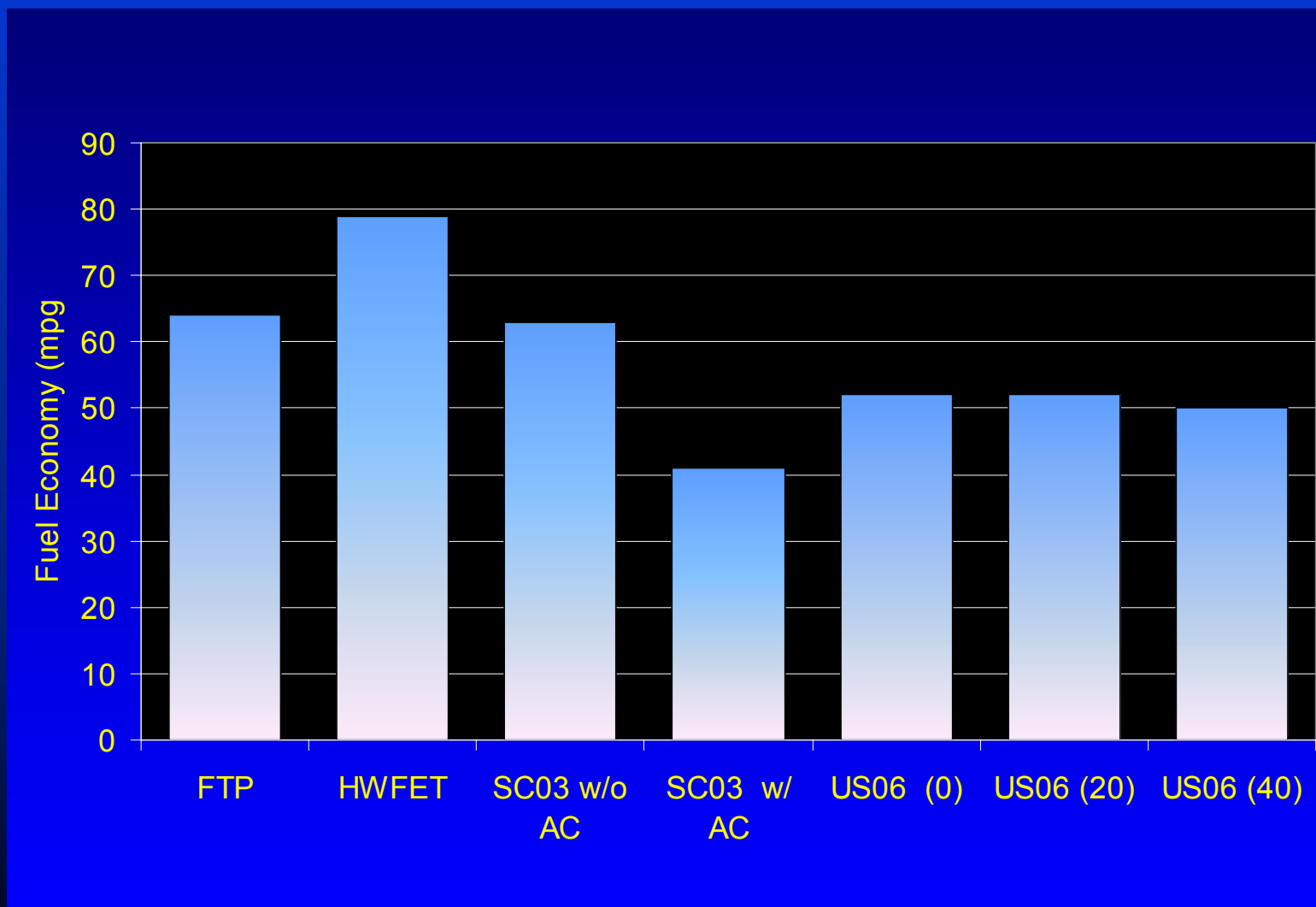
- *Acceleration Tests*
- *City Driving Cycles (AC on/off)*
- *Highway Driving Cycles (AC on/off)*
- *Mountain Driving*

Off-board Battery Testing

- Scheduled to begin in December '00
- ABC 150 Pack Testing
 - charge resistance, pulse power,
 - Ah capacity, driving profiles
- Calorimeter Testing
- Airflow testing



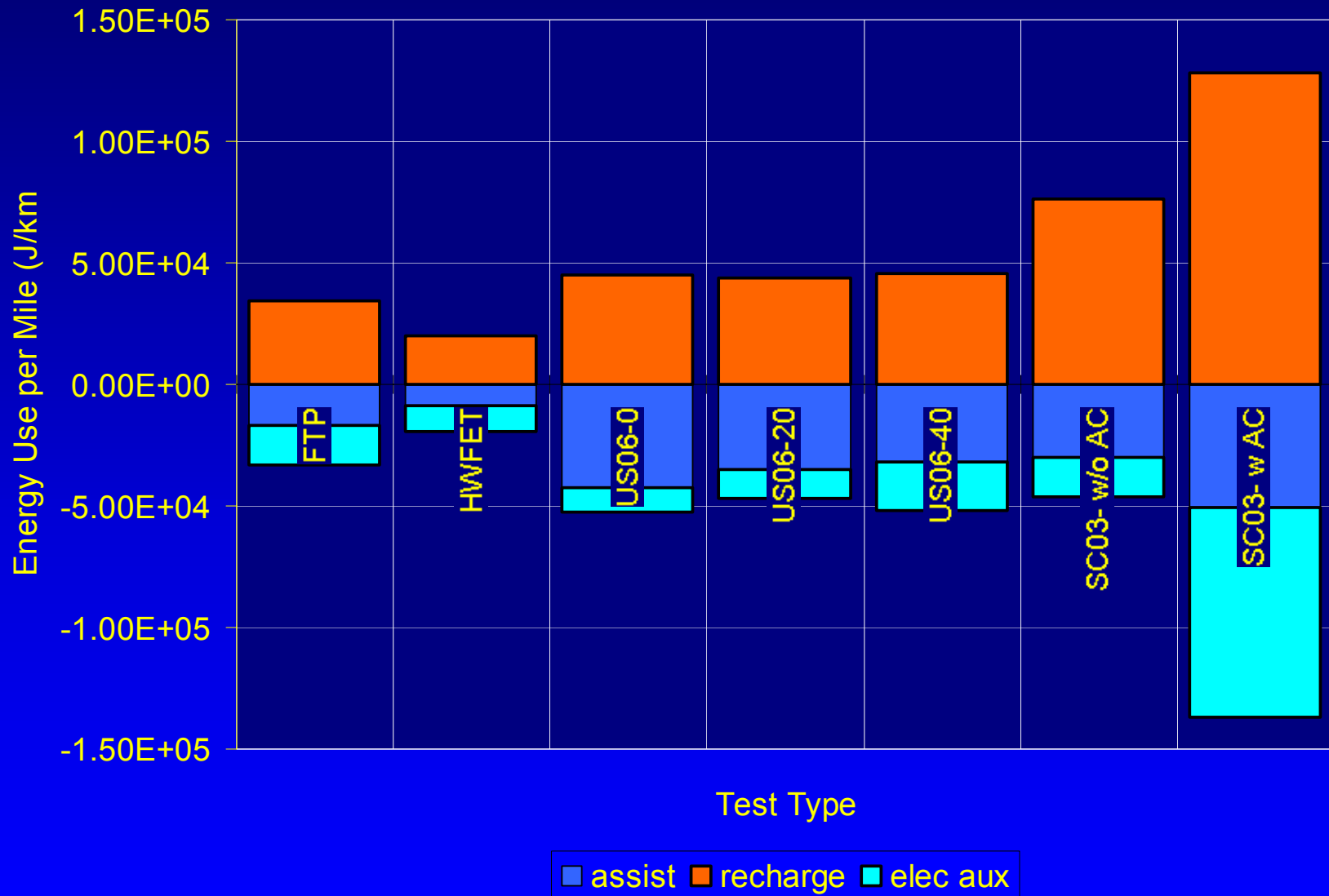
Insight Fuel Economy Testing Results



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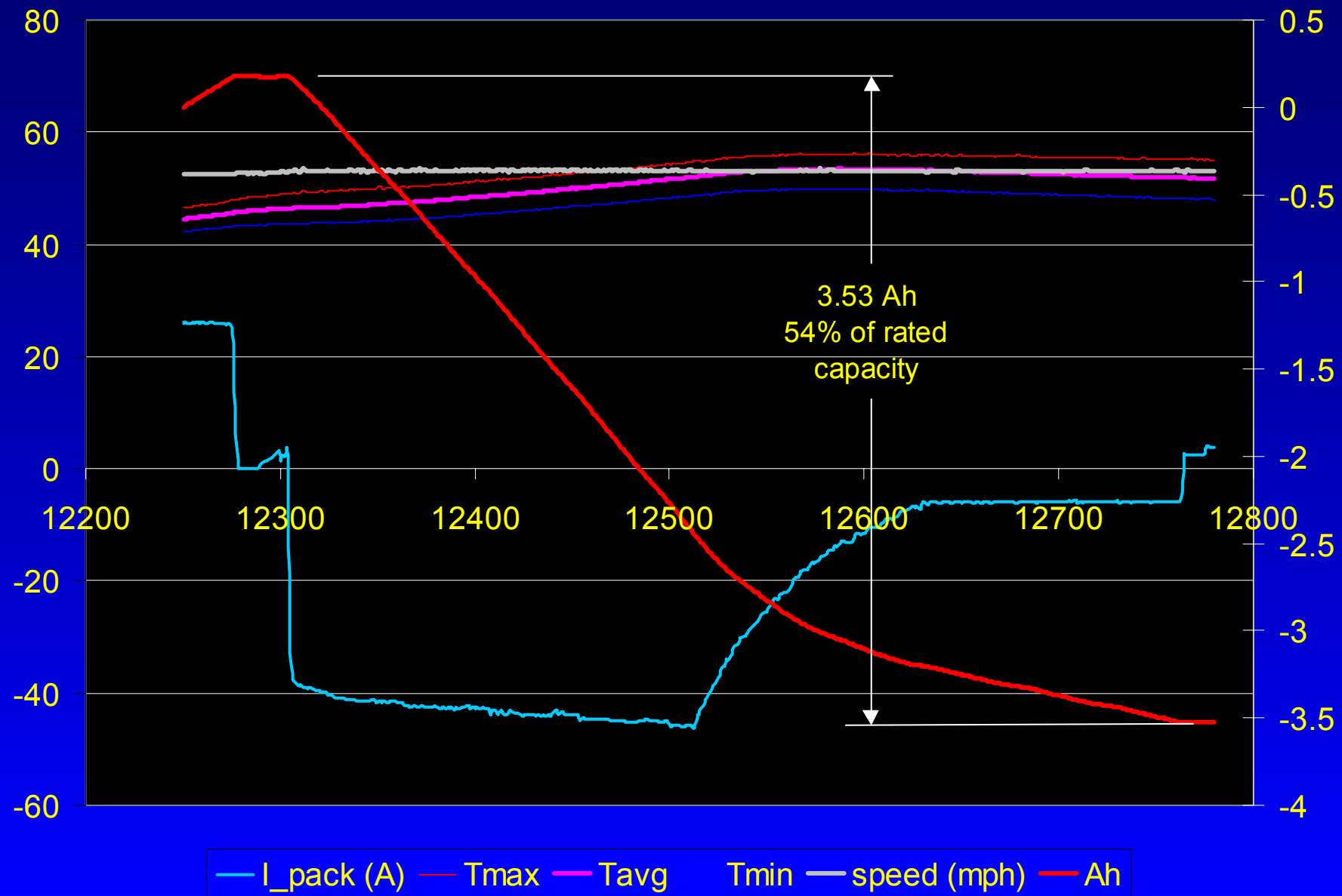


Battery Pack Energy Usage



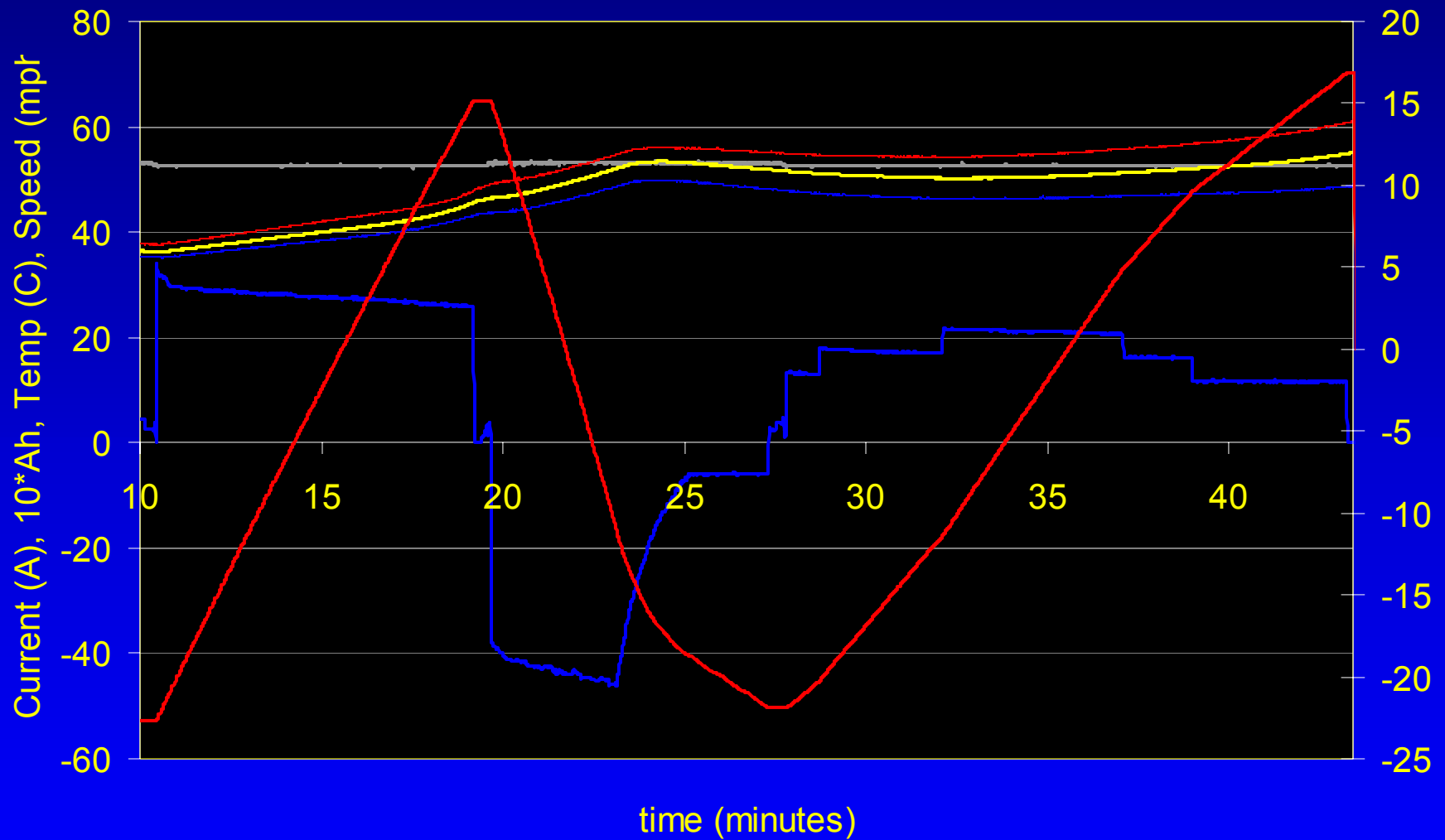
Insight Test Data

Control Strategy Considerations



Insight Test Data

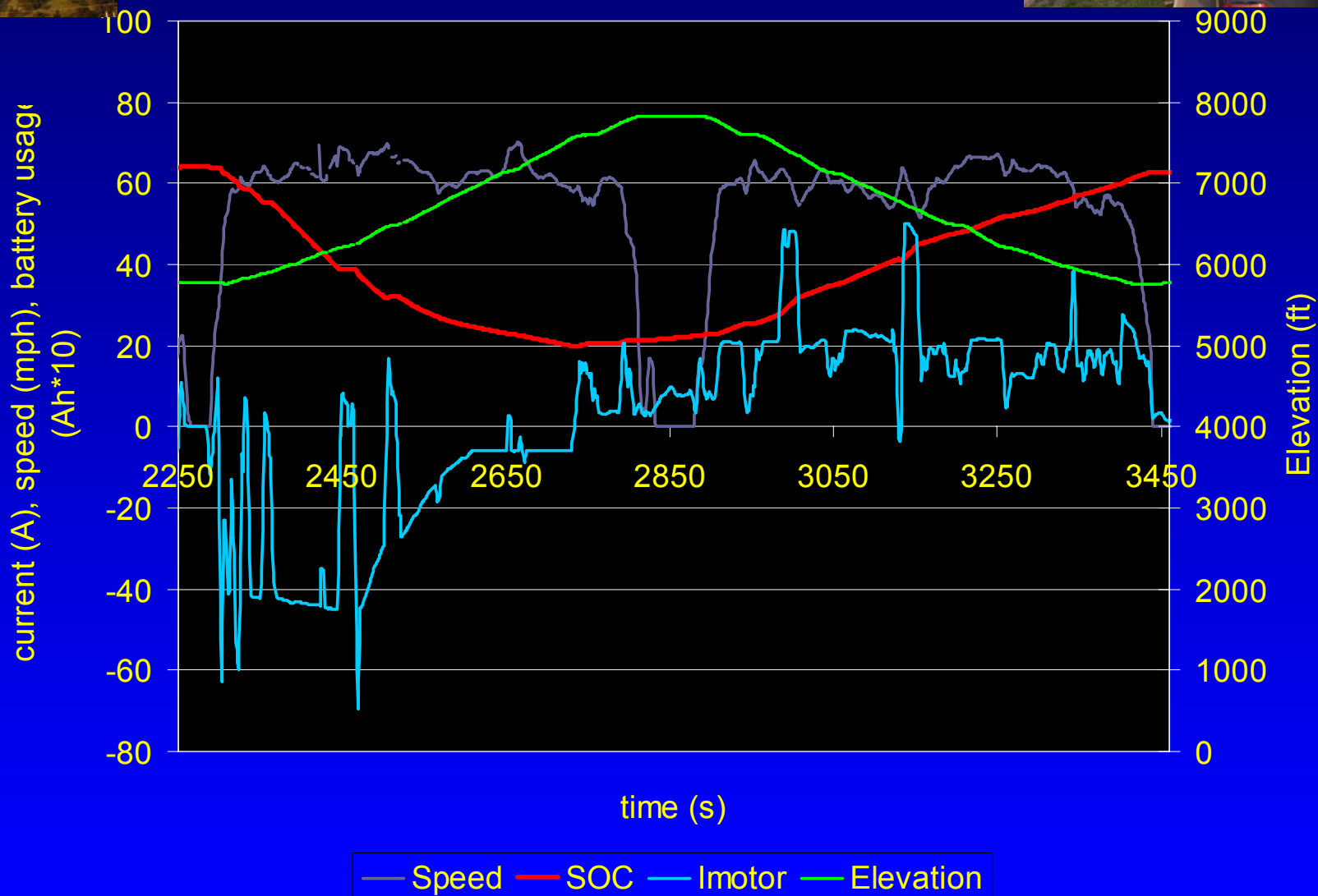
Control Strategy Considerations





Insight Test Data

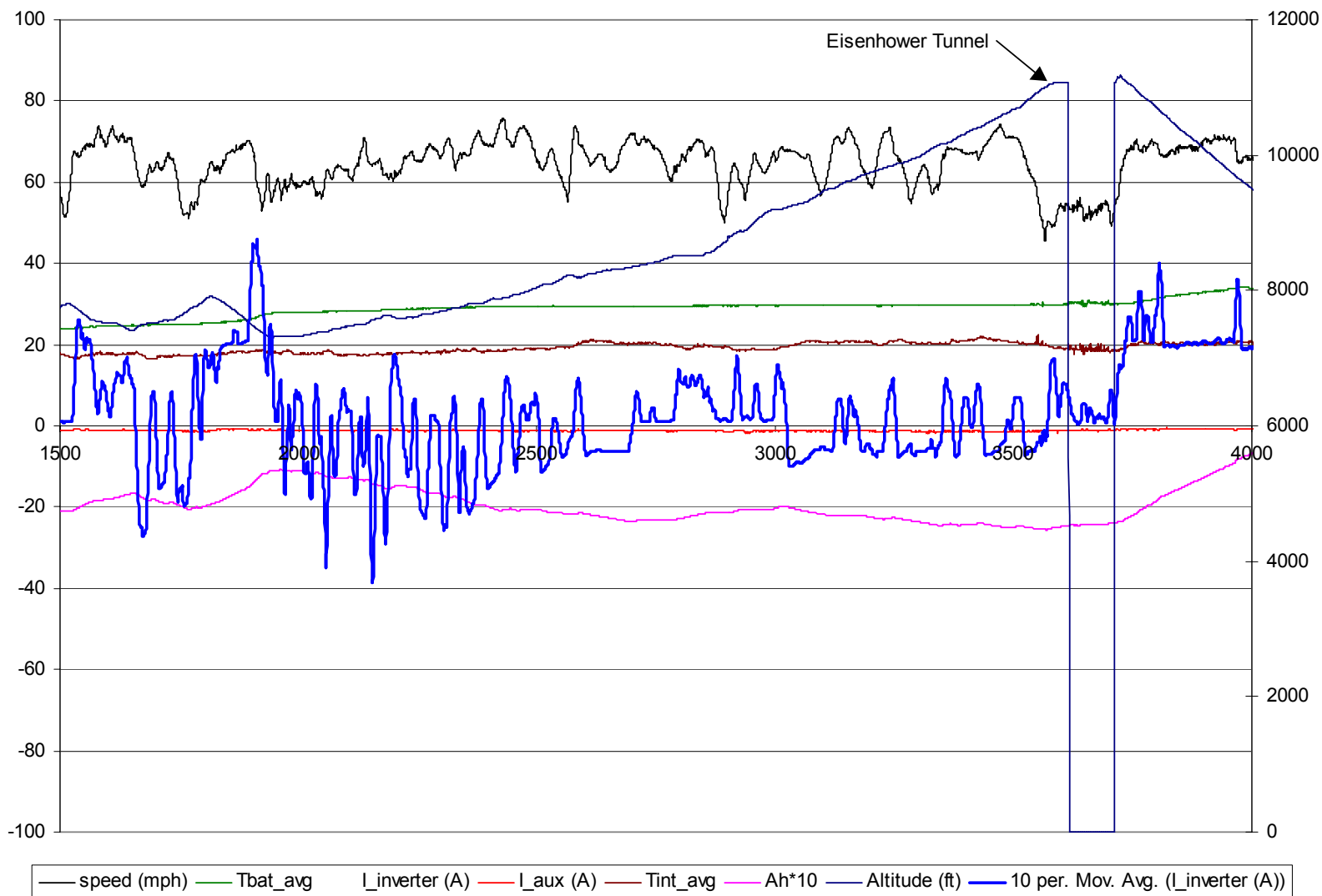
On Road Driving





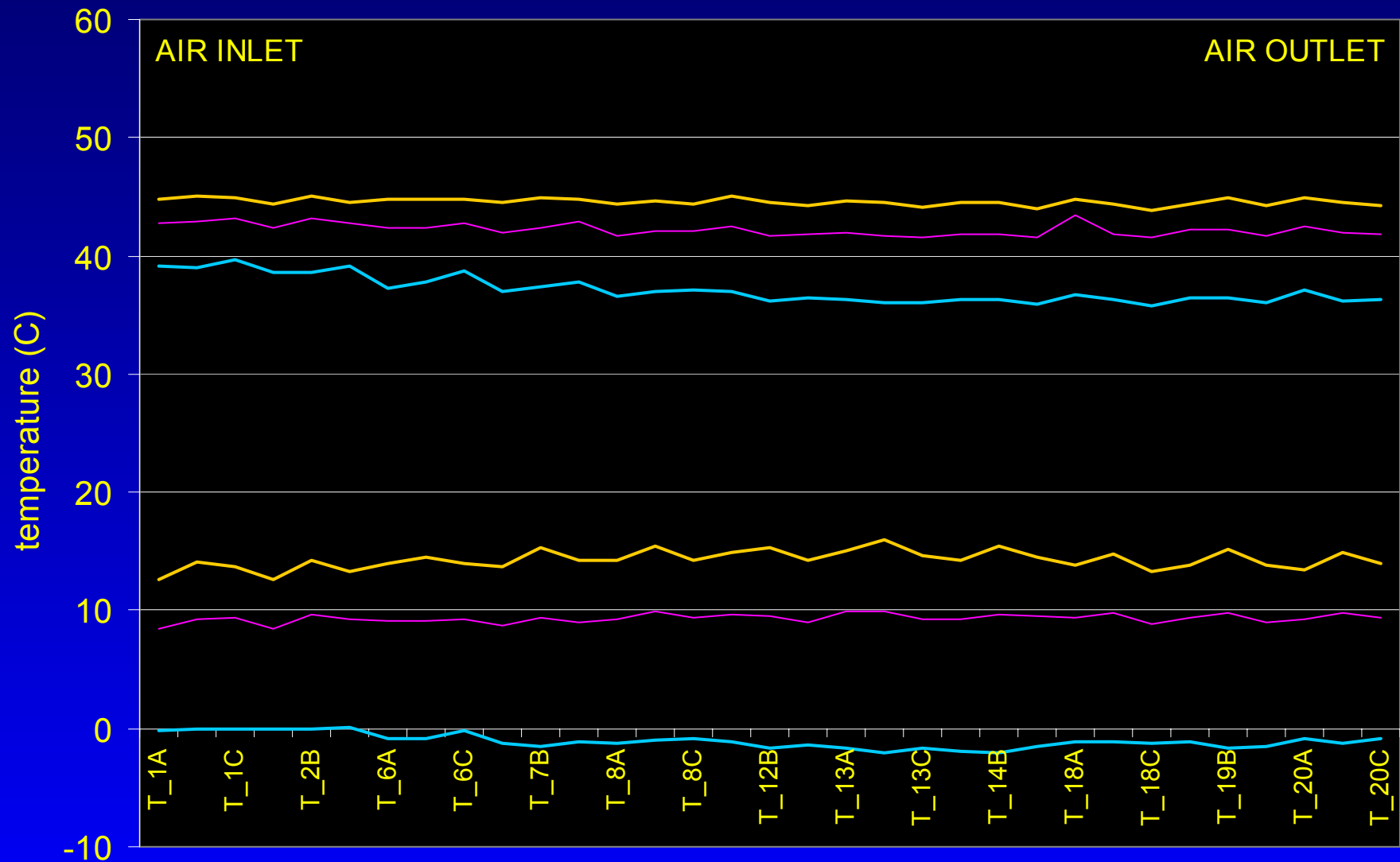
Insight Test Data

On Road Driving - NREL to VAIL



Insight Test Data

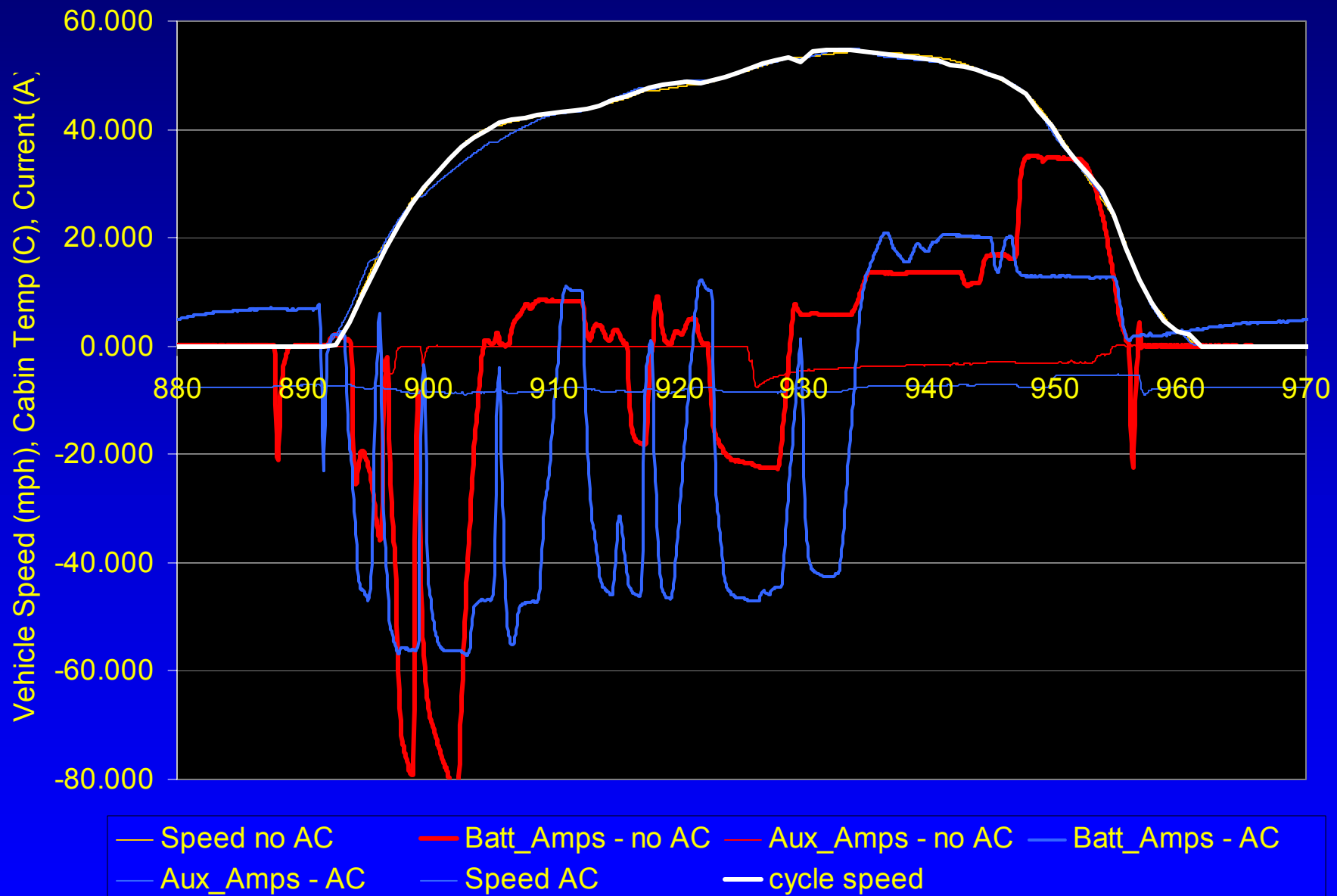
Battery Temperature Effects



— begin 0C — end 0 C warmup — end 0C — begin 40 C — end 40 C warmup — end 40 C

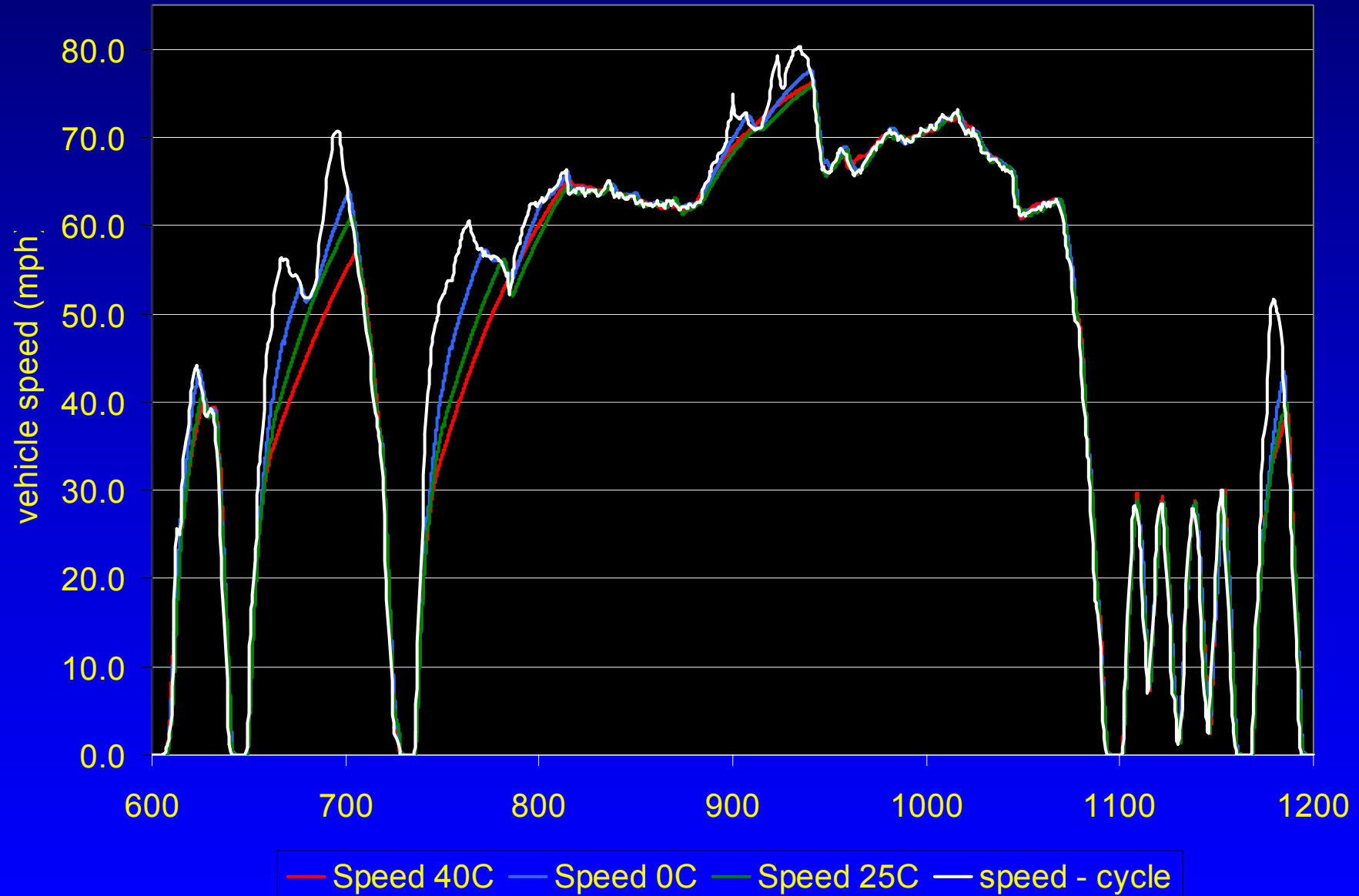
Insight Test Data - Air Conditioning

SC03 with AC on (blue) and AC off (red)



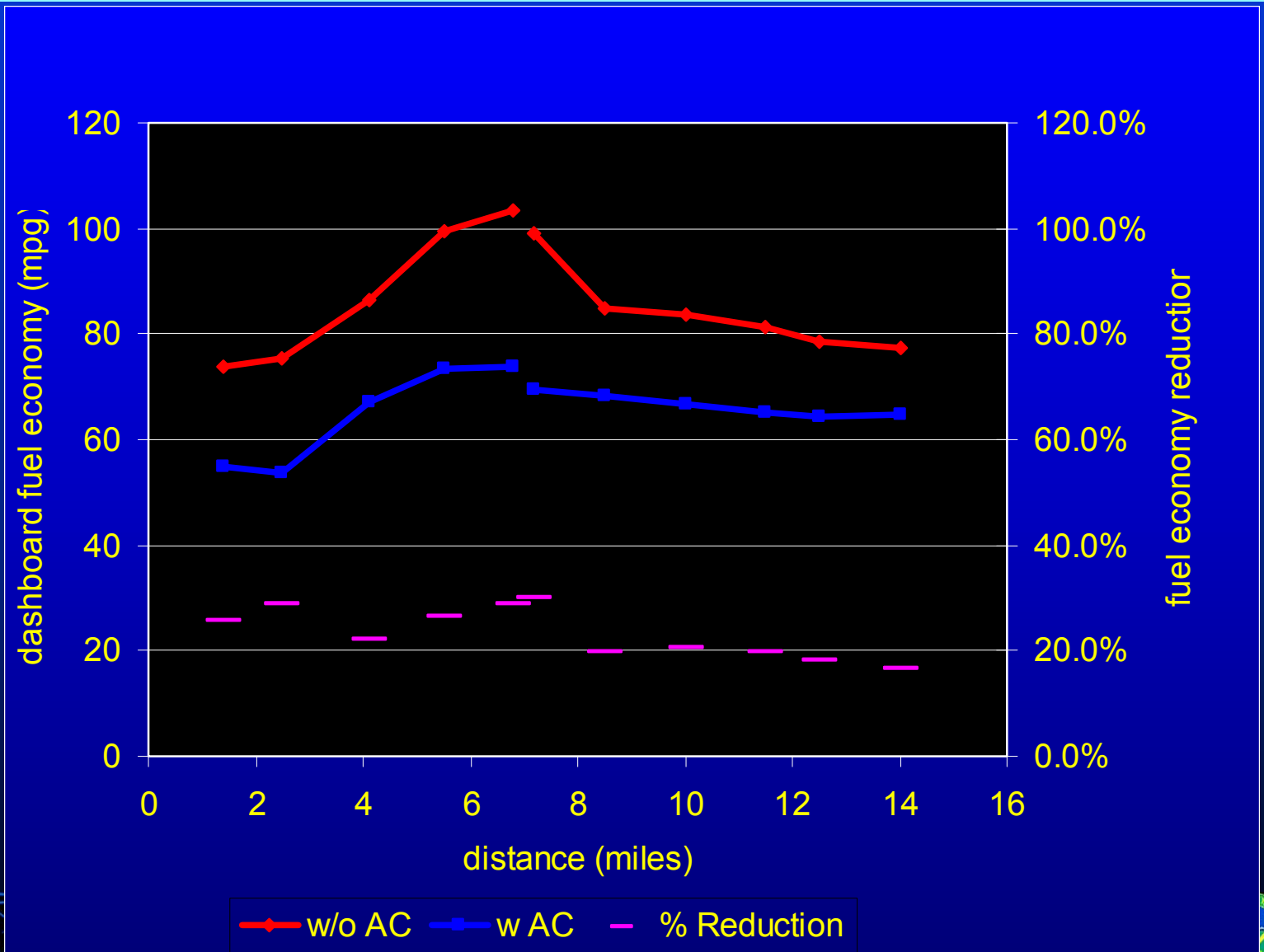
Insight Test Data - Auxiliary Loads

SC03 with AC on (blue) and AC off (red)



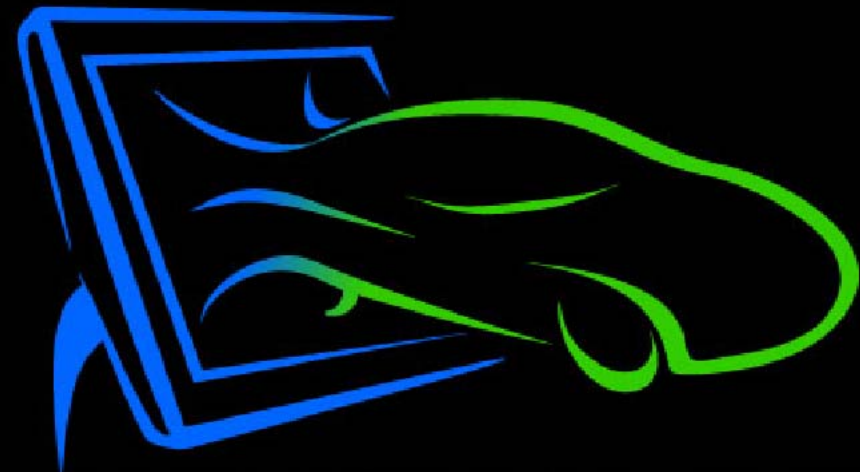
Insight Road Test

Denver City Driving - AC on/off





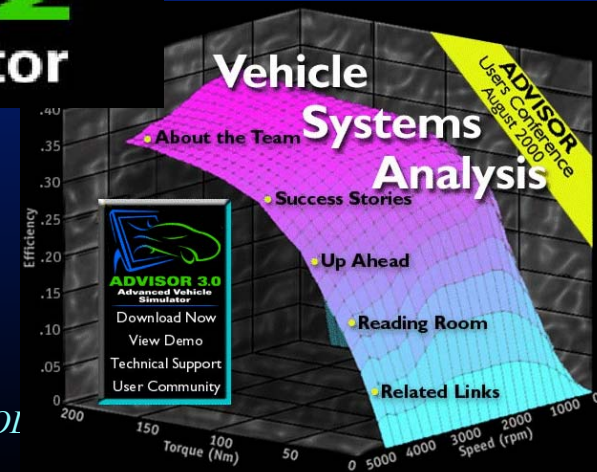
*... including an updated
version of the Honda
Insight model*

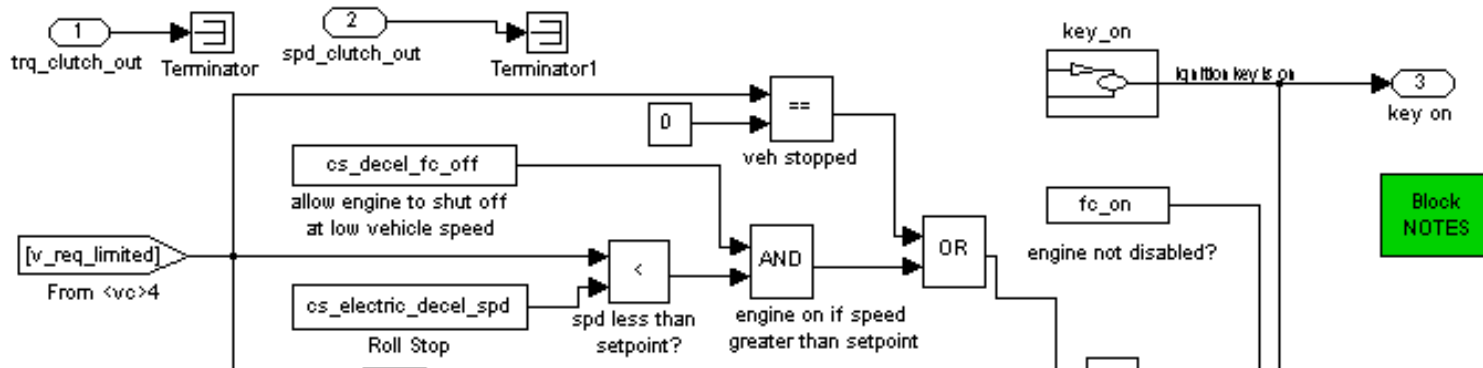


ADVISOR 3.2
Advanced Vehicle Simulator



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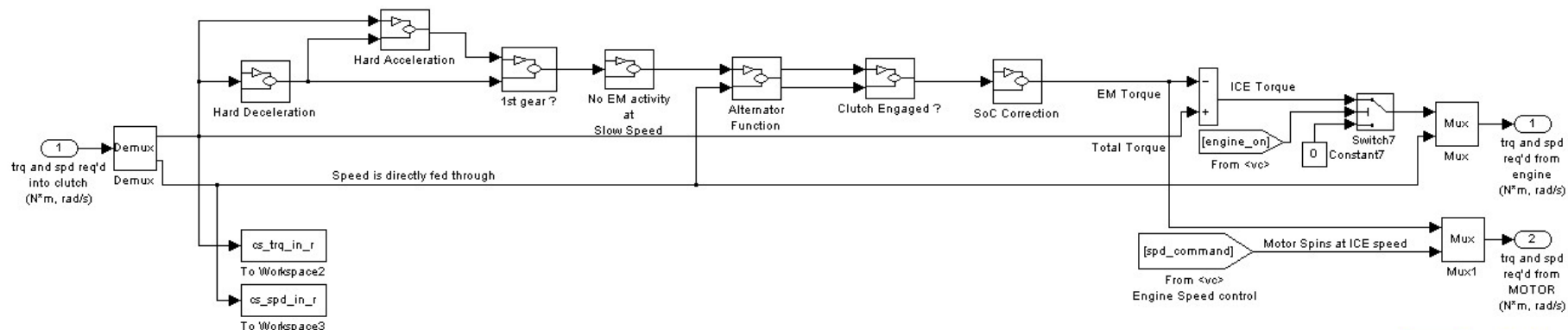


Link: BD_INSIGHT/Insight electric assist control strategy <cs> DIRECT SPLIT

File Edit View Simulation Format



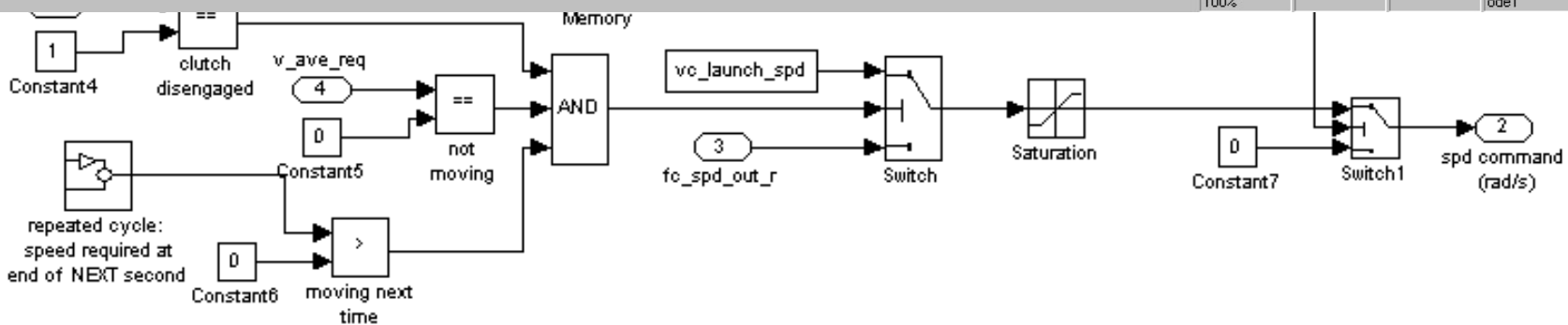
HONDA INSIGHT CONTROL STRATEGY



Ready

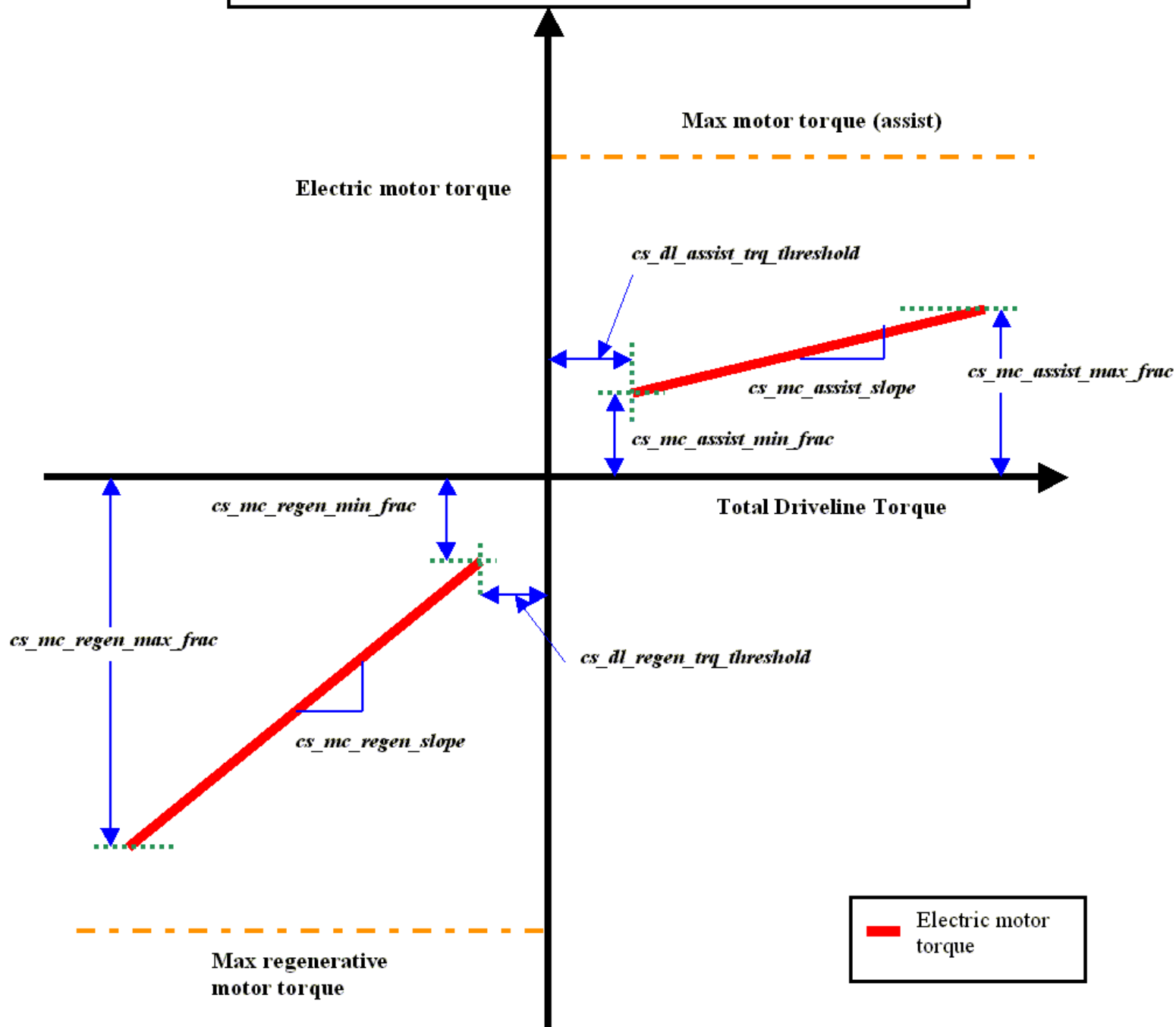
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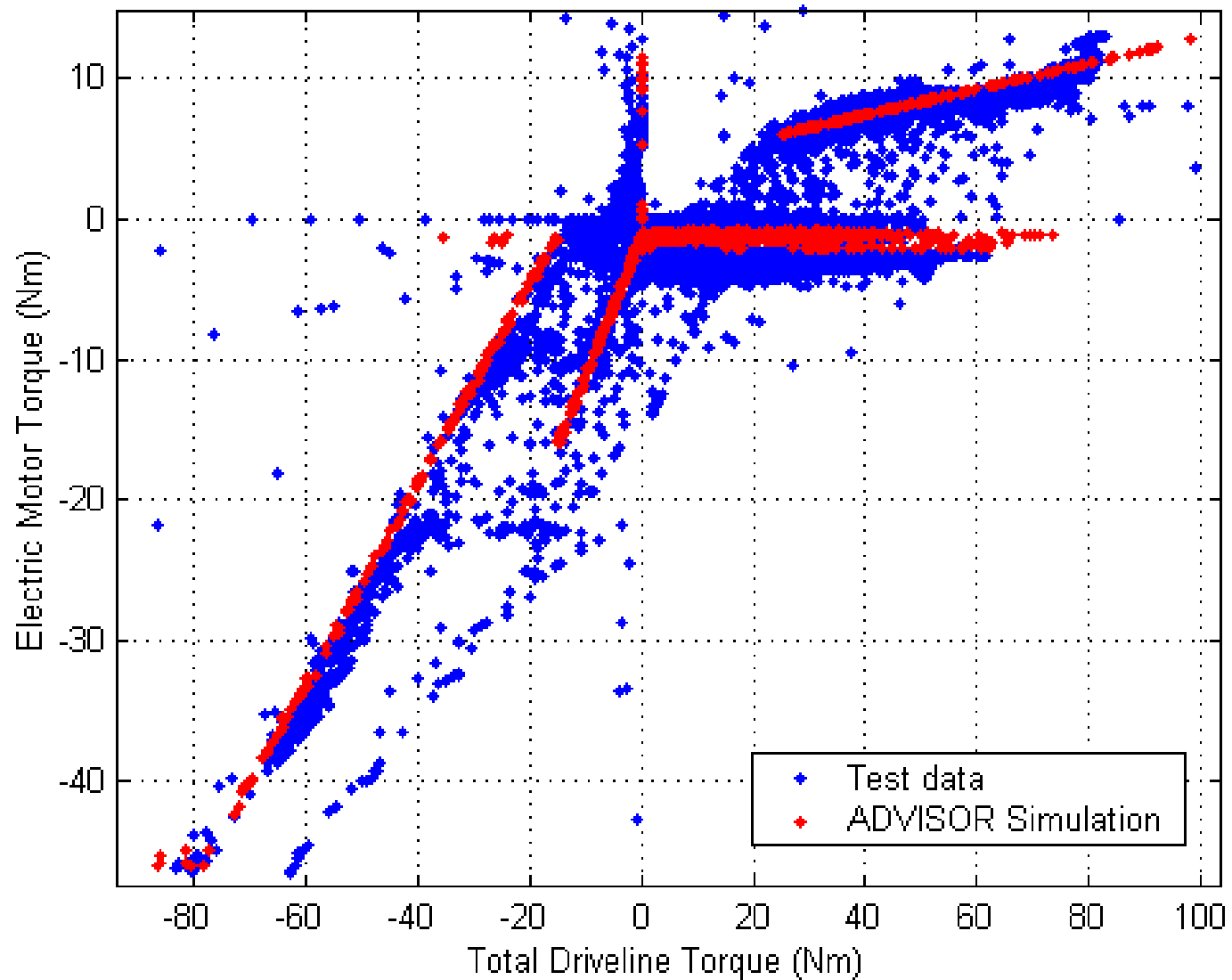


Ready

HONDA INSIGHT ELECTRIC ASSIST CONTROL STRATEGY

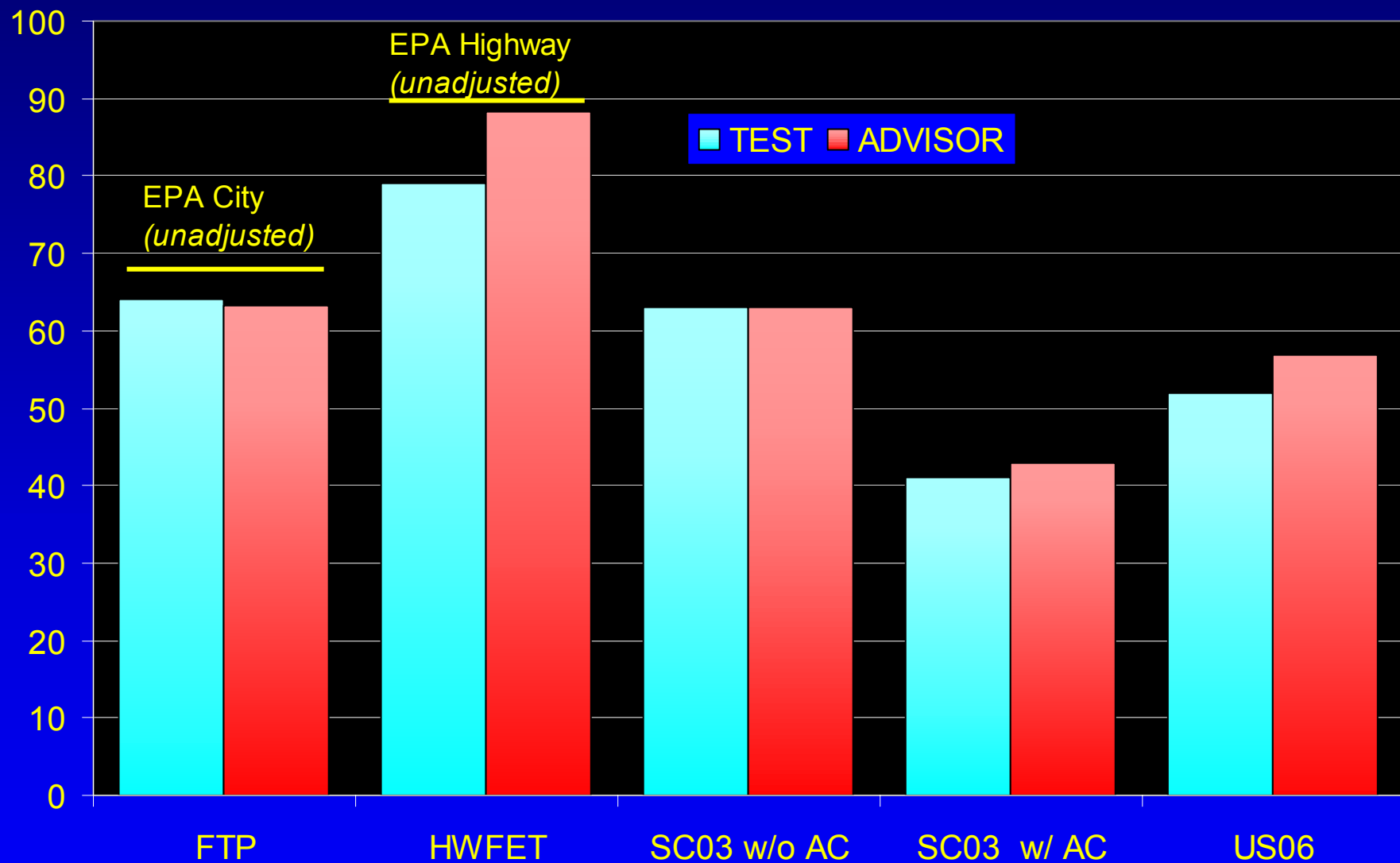


Electric motor torque contribution for the UDDS (simulation Vs test data)

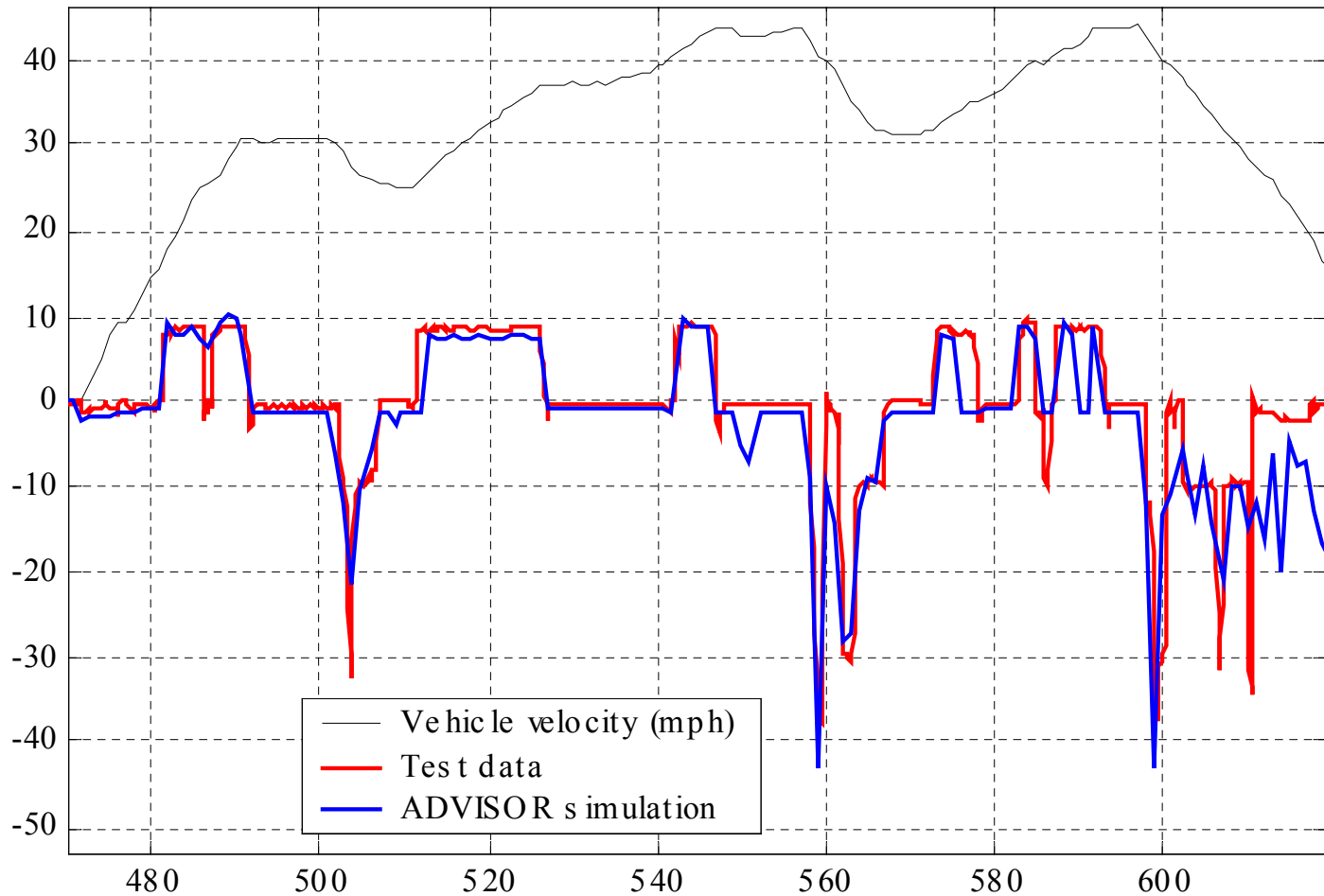


Fuel Economy Comparison

Insight Test Data vs. ADVISOR



Comparison of ADVISOR Simulation to Test Data



Status and Conclusions

Insight testing is complete an updated model now available in ADVISOR 3.2 release

Insight showed 33% drop in fuel economy with Air Conditioning

Battery Pack Control Limits - 60% of 6.5 Ah (144 V)

Insight exhibited adequate battery thermal management design under moderate conditions.

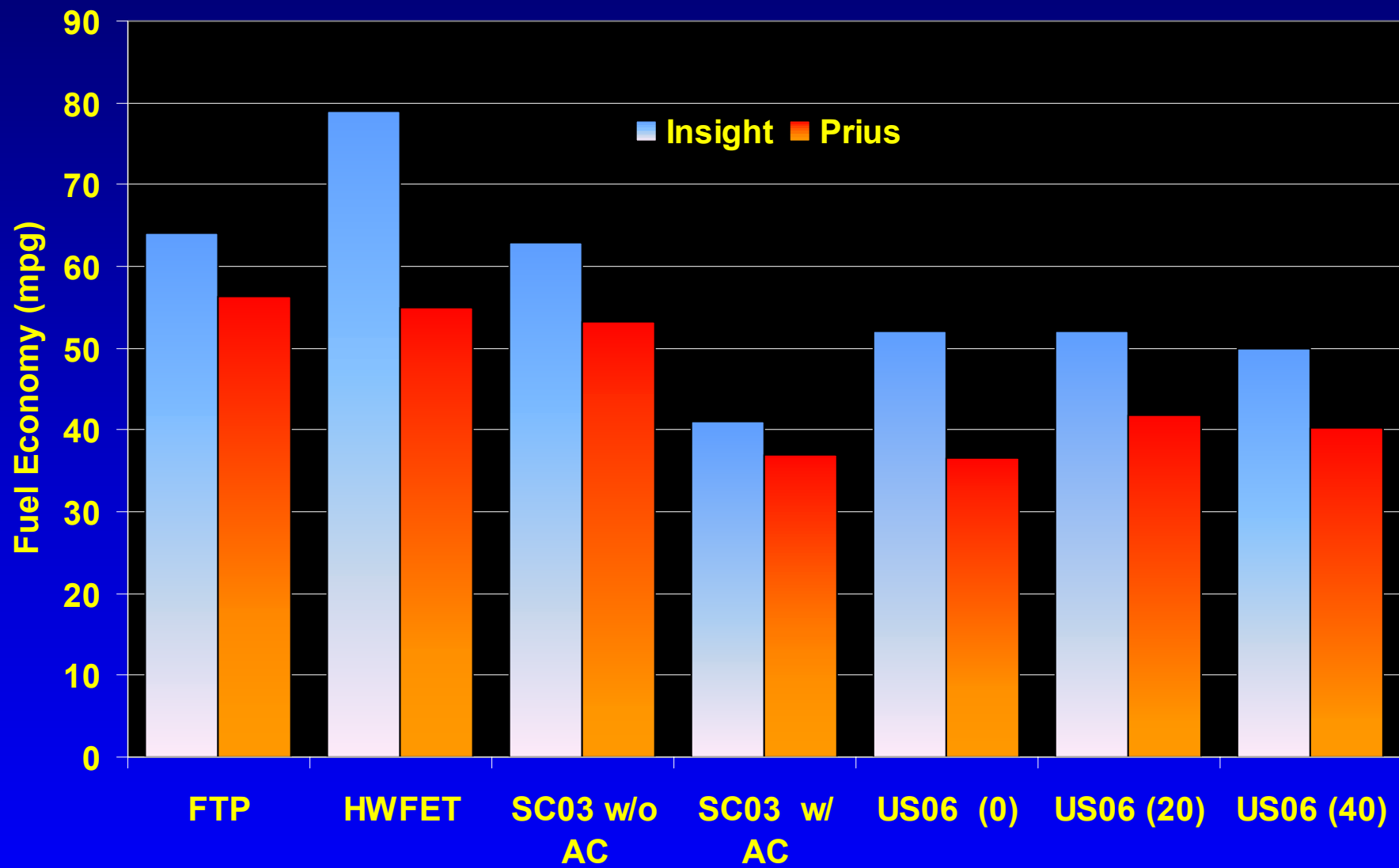
Insight failed to meet US06 aggressive driving trace - problem was exacerbated by:

- low temperature battery internal resistance
- high temperature power limiting for temperature control

Latest ADVISOR model of Insight accurately predicts overall fuel-use and component behavior



Future Directions



Acknowledgements

DOE - Office of Advanced Automotive Technologies
Bob Kirk - Program Manager

Battery Thermal Management Team at NREL

Environmental Testing Corporation - Aurora, CO

Argonne National Laboratory



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